MP MASTER
MA32802

STRUERS

Metallographic Equipment
Geräte für Metallographie
Appareils métallographiques

TENUPOL

T E N U P O L

INDEX

		Page
1 - DESCRIPTION OF THE APPARATUS AND ITS FUNCTIONING.		1
1.1	TENUPOL	1
1.2	Rectifier Unit	4
1.3	Extra Equipment for TENUPOL	4
2 - DIRECTIONS FOR INSTALLATION AND USE		5
2.1	Installation	5
2.2	Directions for Use	6
2.21	Pre-treatment of the Specimen	6
2.22	Thinning, General	6
2.23	Pre-thinning	7
2.24	"Electrolytic blanking"	7
2.25	Final Thinning	8
2.26	Photocell	9
3 - ELECTROLYTES		10
3.1	Table of the Electrolytes	10
3.2	Perchloric Acid Hazard ?	11
3.3	Deterioration of Electrolytes	11
4 - THINNING EXAMPLES		12
4.1	Thinning in the 10 mm Specimen Holder	12
4.2	Thinning in the 3 mm Specimen Holder	12
5 - POLISHING DEFECTS		13
6 - CLEANING AND MAINTENANCE		15
7 - LIST OF SPARE PARTS		16

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1. Description of the apparatus and its functioning.

1.1 TENUPOL

The apparatus consists of the following main parts:

Fig. 1.1. Insulated tank.

Fig. 1.2. Support plate with pump and cooling coil.

Fig. 1.3. Polishing cell.

Fig. 1.4. Nozzle units. (Set of two).

Fig. 1.5. Specimen holder.

Fig. 1.6. Housing for pump motor etc.

Fig. 1.7. Thermometer, +20° to +50° C.

Description of the parts:

Fig. 1.1. Insulated tank. This is made from acid resistant P.V.C. plastic.

Fig. 1.2. Support plate with pump and cooling coil. The support plate, made from acid resistant P.V.C., carries the electrolyte pump (fig. 2.1) and the cooling coil (fig. 2.2). The electrolyte pump is made from acid resistant stainless steel and is a pressure pump, forcing the electrolyte up through an Y-tube (fig. 2.3.) to the two polishing chambers in the polishing cell.
If cooling to a working temperature above app. 15°C is wanted, cold water (from a faucet) is circulated through the cooling coil (fig. 2.2.) which is also made from acid resistant stainless steel. To obtain working temperatures below about 15°C the circulating fluid must be refrigerated. The TENUPOL is designed for being cooled down to about -50°C. (The cooling fluid must then be minus 70°)
A thermometer (fig. 1.7.) is put into the hole fig. 2.4.
The support plate further carries the housing (fig. 1.6.) containing the motor and the electrical parts.

Fig. 1.3. The polishing cell.
The polishing cell is constructed from acid resistant P.V.C. It contains three chambers, separated from each other by the removable nozzle units fig. 1.4. Light from a lamp fig. 3.1. is sent through

a glass window at the rear end of the polishing cell. The lamp has a 3,7 V 1 W bulb with built in lens, fed from a transformer in the housing (fig. 1.6.) A magnifier (fig. 1.9.) at the front end of the polishing cell permits the specimen to be observed with a magnification of app. 2 x. In front of the magnifier (fig. 1.9.) the photocell (see below) may be fitted by means of the two threaded holes (fig. 1.15).
The electrolyte is pumped into the two outer chambers through the tubes (fig. 2.5), is forced through the nozzles of the nozzle units (fig. 1.3), rises in the middle chamber, where the specimen holder (fig. 1.5) is placed, and flows back to the electrolyte tank by an overflow and the tubes (fig. 2.6).

Fig. 1.4. and Fig. 2.7. Nozzle units.
The two nozzle units are made from polyethylene, apart from the nozzles proper, (fig. 2.8.), which are made from teflon. The standard nozzle has a bore of 1 mm dia. but extra nozzle units with a bore of 2,5 mm can be delivered (see below).
The nozzle is surrounded by a helix of platinum wire (cathode), (fig. 2.9.) which is connected to a plug (female). This is connected to a banana plug, when the nozzle unit has been mounted in the polishing cell. Through the housing (fig. 1.6.) this banana plug is in connection with the negative terminal of a rectifier unit or other suitable DC-source. The nozzle unit is fastened in the polishing cell by the flange (fig. 2.11), which is pressed into a recess in the polishing cell. (See section 2.22 "Thinning, general".)

Fig. 1.5. and fig. 2.12. Specimen Holder.
The standard specimen holder is designed for thinning specimens of 3 mm or 2,3 mm outer diameter, max. thickness o,5 mm. The specimen is placed in a platinum fixture, which by a strip of stainless steel and a bush is in connection with a banana plug. (fig. 1.11.)
This is to be connected to the positive terminal of the rectifier unit
The two halves of the specimen holder are assembled by pressing the collar flange (fig. 2.14) into the recess (fig 2.15).
As an extra can be delivered a specimen holder with an aperture of 10 mm dia. (see below).

Fig. 1.6. Housing for pump motor etc.

This box contains the pump motor, solid state speed control for the pump motor, a transformer (220V/110V/3V) for supplying power to motor, lamp and photocell, a noise filter, a socket, where the board with the photocell electronics may later be plugged in, a fuse (see below) etc.

On the front plate of the box are found a mains switch (fig. 1.12) with pilot lamp, a switch for polishing current and pump (fig. 1.13) with a pilot lamp, and an adjustment knob for varying the speed of the pump motor. This takes place by means of a thyristor circuit (printed wiring). The scale goes from low speed (0) to high speed (10). If the regulation for the motor does not work well, it may be ajusted on the two potentiometers situated on the regulation board in the housing. They may be found close to the polishing cell. The upper one is for fine ajustment. When the switch (fig. 1.3) is closed, the pump starts at a comparatively high speed for 2 seconds, in order to fill the polishing chambers with electrolyte. Then the speed is automatically changed to that set on the knob (fig. 1.4). After the 2 seconds the pilot lamp will light up, indicating that the polishing circuit has been closed.

From the rear side of the housing the following cables come out: mains cable (fig. 3.2.), cable to rectifier (fig. 3.3.), with plug for the POLIPOWER, LECTROPOL or MOVIPOL OPERATING UNIT (see further section 2.1), two leads with black banana plugs (fig. 3.4) for nozzle units, lead with red banana plug (fig. 3.4) for nozzle units, lead with red banana plug (fig. 3.5) for specimen holder and cable for lamp (fig. 3.6). Also on the rear side is found a connector (fig. 3.7) for the connection to the photocell.(Extra outfit, see below).

Electrical specifications.

Mains voltage: 220V or 110V AC. The apparatus is delivered from the factory for the mains voltage indicated on the name plate on the rear side of the box. As it is always delivered with a built-in transformer, change-over to another mains voltage is possible by a simple change of connections.

Pump motor: commutator motor, 220 V, 80 W max.

Illumination lamp on polishing cell: 3,7V, 1W.

Fuse: 0,5 A

ATTENTION: The fuse is situated inside the box. To renew the fuse, it is necessary to take off the cover (4 screws).

1.2. Rectifying unit

For the polishing cell of TENUPOL a rectified current ("thinning current") of 0 to 2,5 A at a voltage of 0-100 V is needed. In principle, this may be taken from any suitable rectifier. We recommend to use the POLIPOWER but the Operating Unit of either LECTROPOL (code word LECOC) or MOVIPOL (code word MOVPO) may also be used.

1.3. Extra equipment for the TENUPOL

10 mm specimen holder.

In place of the standard specimen holder for specimens of 3 mm (2,3 mm) dia. a holder for specimens of diametres from 12 to 23 mm can be put in. The thinned area is 10 mm dia.

The "10 mm" specimen holder is used in cases, where it is wanted to cut a small pieses, less than 3 mm (2,3 mm), from the thinned sample. It is also used for pre-thinning of specimens, which are later to be thinned in the 3 mm (2,3 mm) specimen holder. The "10 mm" holder is also used for "electrolytic blanking" of the 3 mm (2,3 mm) blanks (see below).

Nozzle Units 2.5 mm.

Instead of the normal nozzle units with an internal diameter of 1 mm, nozzle units with 2.5 mm internal diameter can be inserted by the user. (Code word TENAH).

The 2.5 mm nozzles are used for polishing 10 mm dia. areas and moreover when a nearly stagnant electrolyte is wanted.

Equipment for "electrolytic blanking" of 3 mm (2,3 mm) dia. specimens.

When a sample has been ground down or thinned electrolytically to a thickness of 0,1 to 0,5 mm, a blanking becomes necessary for getting specimens to put into the 3 mm (2,3 mm) specimen holder. This may be done in an ordinary blanking tool, but when using the special outfit (code word TENKI) it is possible to cut out the work piece electrolytically, which ensures, that absolutely no deformations are introduced. Two to five discs of special tape are stuck onto the piece, from which the 3 mm (2,3 mm) specimens are to be cut, and the piece is mounted in the 10 mm holder. After about 10 minutes of electropolishing specimens of 3 mm (2,3 mm) dia., ready for the final thinning, are obtained.

Photocell (see also section 2,26)

If it is wanted to stop the thinning automatically as soon as a hole is formed in the specimen, a photocell (code word TENOF) may be mounted on the polishing cell in front of the magnifier (fig. 1.9.) In the box for the pump motor is provided a socket for plugging-in the electronic circuit for the photocell.

As soon as a very small hole appears in the specimen, the photocell equipment will switch off polishing current and pump and activate a buzzer.

The complete photocell with the corresponding printed circuit can be easily installed by the user.

Refrigerating unit.

For electropolishing certain materials a lower temperature is necessary than obtainable by circulating cold water in the cooling coil. In such cases a cooling machine must be used, which is able to circulate a cooling fluid through the coil. By using suitable cooling equipment temperatures down to -50°C can be obtained. Struers can deliver, as an extra equipment, a refrigerating unit, e.g. type FK by Gebr. Haake; this delivers a cooling fluid of ÷15°C, and will bring the electrolyte temperature below ÷10°C.

2. Directions for installation and use

2.1 Installation.

First of all, see that the voltage stated on the name plate on the rear side of the box corresponds to the local mains voltage. (See section 1.1. "Electrical specifications.")

Then mount a plug on the mains cable so that:

Blue lead is connected to phase,
black lead is connected to neutral and
yellow/green lead is connected to ground.

If a DC-source is to be used, where the connector on the polishing current cable does not fit, mount another connector, so that:

blue lead is connected to positive terminal and
black lead is connected to negative terminal.

The cooling coil is connected to water tap or refrigerating unit as required by means of two flexible tubes.

As to installation of photocell please refer to special instructions enclosed with the photocell.

2.2. Directions for use.

2.21 Pre-treatment of the specimen.

The aim of the pre-treatment is to prepare disc of 3 mm (2,3 mm) dia. thickness 0,1 to 0,5 mm. Methods such as spark-machining or mechanical turning and cutting are well known.

The preparation can also be done on the TENUPOL (see 2.23 and 2.24) the original sample being a cut-off disc, thickness max. 1 mm, diameter max. 23 mm. Such a disc may e.g. be cut on the DISCOTOM cut-off machine in the following way: a plane metal block is clamped as a stop at a distance of 0,4 - 2 mm from the side of the cut-off wheel. A plane face on the metal, which later is to be thinned, is pressed against the stop block and clamped. When cutting-off in the normal way, the metal between the stop block and the cut-off wheel will be parted off as a plate. The metal stop block takes care of the cooling of the plate and ensures, that the cut-off wheel is not bent. The parted-off plate is now ground down on abrasive paper, e.g. on KNUTH-ROTOR. It is recommended to fix the plate to a plane block of metal by means of double-adhesive tape. It is ground first on one side then on the other on the rotating disc, finished with grain 600 paper and should then be max. 1 mm thick.

2.22 Thinning, general.

About 1 liter of the electrolyte suitable for the metal in question (see section 3 and 4) is poured into the electrolyte tank. The temperature is adjusted (section 4). The nozzles are placed in the polishing cell. Usually 1 mm nozzles are used for 3 mm (2,3 mm) specimens and 2,5 mm nozzles for the 10 mm specimen holder, but the 2,5 mm nozzles may also be used for the 3 mm (2,3 mm) specimens if a nearly stagnant electrolyte is wanted.

The nozzle units are removed by being pressed towards the center of the open middle chamber, the specimen holder being drawn out, and are fixed by the opposite movement. The nozzle units are pressed home by pressing the specimen holder down between them. The specimen is placed in the holder, so that it makes contact with the platinum. The holder is closed and slid down into the cell. If the photocell equipment shall be used: see 2.26. The DC-source is switched on and set to the value chosen for the polishing. Also the pump speed is set to the chosen value, 0-4: slow, 4-6: middle, 6-10: fast. The mains switch ("Mains") is closed, whereby the illumination lamp lights up. The switch "Thinn" is closed. The pump now starts. After 2

seconds the polishing chambers are filled and when the pump speed drops the polishing circuit is closed automatically. It is now possible to readjust current, voltage and pump speed. If in doubt how much electrolyte is passing the cell the user may lift the front edge of the support plate a little to watch the flow. The specimen is watched through the magnifier and the progress of the polishing observed. Some materials should be bright and shining during polishing, others should be covered by a viscous anodic layer (colour: yellowish to black) if the polishing conditions are well chosen. The proper moment to stop the progress depends on, whether pre-thinning (see point 2.23) "electrolytic blanking" (see point 2.24) or final thinning (see point 2.25) is going on. The process is terminated either by the photocell at the moment of perforation or by switching off the motor and polishing current by the switch "Thinn". The specimen holder is at once drawn up and opened in a rinsing bath, whereby the specimen will fall out.
If another polishing is not to be done at once, it is recommended to switch off also the mains voltage and the DC-source.

2,23. Pre-thinning.

The cut-off and possibly preground plate can be pre-thinned by means of the specimen holder providing bilateral polishing of an area of 10 mm dia. (Extra equipment. Code word TENHO). To fit the specimen holder, the plate must be not more than 1 mm thick and not more than 23 mm dia. The 2,5 mm nozzles are used (Extra equipment: Code word TENAH). For polishing procedure see section 2.22. The polishing should not be carried on to perforation. In most cases 5 minutes will suffice. After pre-thinning the thickness should be 0,1 - 0,5 mm. thickness should be 0,1 - 0,5 mm.

2.24 "Electrolytic blanking."

When equipped with the 2.5 mm nozzles the TENUPOL may be used for cutting out 3 mm (2,3 mm) specimens electrolytically in the 10 mm specimen holder. The larger specimen, which should be 0,1 - 0,5 mm thick, is first degreased in alcohol. One side of the specimen is covered completely with a special acid-resistant tape, having an acid-resistant adhesive. On the other side are stuck 1-4 discs of tape of 3 mm (2.3 mm) dia. within a circle of 10 mm dia. The tape is available as a kit (Extra equipment. Code word TENKI). The tape must be pressed securely against the metal. The specimen is now put into the specimen holder, so that there is a free area, which

can be polished away, around the small tape discs.
When the holder has been put into the cell the cathode on the side where the specimen is completely covered is disconnected by pulling out the banana plug. The specimen is then polished in the usual way until the exposed area has disappeared. The 3 mm (2,3 mm) metal specimens will now be present under the tape discs. They are freed, washed and are ready for the final thinning.

2.25 Final thinning.

This will normally consist in polishing of 3 mm (2.3 mm) dia. specimens with the 1 mm nozzles. The procedure is as under 2.22. The polishing is carried on until a small hole appears, and must be stopped as soon as the light breaks through the specimen, which is illuminated from behind.
If the process is stopped manually, it is necessary, with the hand on the switch, to watch the specimen constantly towards the end of the process. The switch is flipped immediately, when light is seen.
The process can be terminated automatically by means of the photocell (Extra equipment. Code word TENOF) which is mounted on the polishing cell and will break the current and activate a buzzer.

As soon as the polishing is finished the specimen holder must be drawn out and opened in a small bath of e.g. methanol, ethanol or destilled water, kept ready close to the cell. From this the specimen is transferred to a bath of e.g. methanol or ethanol by means of a pair og tweezers. It may then be laid on a piece of filter paper, where it dries in a couple of seconds and is ready for examination or storing.

Ferromagnetic materials may cause blurred pictures by distorting the electron beam, if they are present in appreciable quantities and are not symmetrically arrenged with respect to the beam.
In order to secure sharp images, it is necessary either to arrange the specimen symmetrically or to place only very small amounts of ferromagnetic material on the specimen holder of the electron microscope.
The first condition demands, that the edge of the specimen is of uniform thickness and that the hole is at the center.
The second condition can be fulfilled by using the following procedure.

If the specimen, prior to the final thinning, is prethinned to a small thickness (below 0,1 mm) the mass of the finished specimen will be small. If sufficiently small masses are not achieved in this way, it will be necessary to carry on the thinning to perforation in the 10 mm specimen holder in the normal way. From the extremely thin foil obtained a small piece may be cut with a sharp knife, for introducing into the electron microscope on a grid.
Thinned specimens may be kept under vacuum in a dissicator with silica gel. In most cases they can also be kept in glycerol, which will protect them against the action of the atmosphere.

2.26 Photocell. (Directions for use)

To get full advantage of the photocell device, i.e. to enable it to stop the polishing while the hole in the specimen is small, a knob for adjusting the sensitivity is provided. By means of this the maximum sensitivity possible under the prevailing conditions can be set. These may change from polishing to polishing, because stray light or a rise in temperature may increase the dark current of the photocell so much that the limit is reached, where the photocell device responds and interrupts the polishing process.
The photocell is very sensitive and it is recommended not to place the TENUPOL in direct sunlight.
The procedure is as follows:
The specimen is inserted and the apparatus is prepared for thinning in the normal way, but the D.C. source is not connected. The knob on the photocell housing is turned anti-clockwise as far as it will go. Then the two switches on the motor housing are closed, and after about two seconds the red lamp lights up. After two seconds more the photocell circuit is automatically switched on.
Then the knob is turned clockwise slowly until the sensitivity is so high, that the photocell device just responds to the dark current alone and the alarm is heard. Then the knob is turned one scale division back again, and the device will now be set for the maximum sensitivity possible for the subsequent thinning operation. The D.C. source is now connected and the thinning procedure is started as usual. When the alarm is heard, the motor and the polishing current will automatically be switched off and the specimen must be removed quickly for rinsing.
The pump motor must be set at so high a speed, that the electrolyte rises well above the specimen. If not, the light beam may be refracted so that it does not reach the photocell.
If the polishing chamber is cooled to a very low temperature, ice may form on the windows. This must be wiped off from time to time, e.g. with alcohol, so that the light is not diffused.

3.1 ELECTROLYTES for LECTROPOL, MOVIPOL, ELYTOPOL and TENUPOL

A-2 Steel, Stainless Steels, Aluminium and Al-Alloys, Nickel, "Nimonic" Tin, (Beryllium, Titanium, Zirconium, Uranium).
All-round Electrolyte for LECTROPOL and MOVIPOL.

A-3 Molybdenum, Titanium, Zirconium, Vanadium.
LECTROPOL, MOVIPOL, ELYTOPOL.

A-5 Uranium, Lead, Lead-Tin, Lead-Tin-Antimony-Alloys
LECTROPOL, MOVIPOL. All-round Electrolyte for ELYTOPOL

A-6 Steel, Aluminium and Al-Alloys, Cobalt and Co-Alloys.
LECTROPOL, MOVIPOL, ELYTOPOL.

A-7 Aluminium and Al-Alloys, Stainless Steel.
Specially Suited for TENUPOL.

A-8 Iron, Stainless Steel, Nickel, Cobalt, Zirconium.
LECTROPOL. All-round Electrolyte for TENUPOL.

AC-2 Cast Iron, Magnesium, Mg-Alloys, "Nimonic", Nickel, Low Carbon Steel, Stainless Steel, Beryllium.
LECTROPOL, MOVIPOL.

B-1 Germanium.
LECTROPOL, MOVIPOL.

C-1 Zinc, Zinc-Alloys, Magnesium, Mg -Alloys.
LECTROPOL, MOVIPOL.

D-2 Copper, Copper-Alloys, Brasses.
LECTROPOL, MOVIPOL, ELYTOPOL, TENUPOL.

E-2 Copper-Alloys, Bronzes, Brasses.
LECTROPOL, MOVIPOL, ELYTOPOL.

E-5 Steel with Disturbing Impurities, Low Carbon Steel, Examination of Inclusions, (Cast Iron), Bronzes, Brasses.
LECTROPOL, MOVIPOL, ELYTOPOL.

F-1 Tungsten.
LECTROPOL, MOVIPOL, ELYTOPOL.

3.2. Perchloric Acid Hazard?

It cannot be pointed out too strongly that all Struers-electrolytes can be used without any danger.
We have a very thorough examination of the possibilities of explosions and have ascertained, by practical experiments, that no element of risk is at hand as long as our electrolytes are used. Where used at all, the perchloric acid is used together with safe compounds and in so low concentrations, that no dangerous reactions are possible.

3.3. Deterioration of Electrolytes.

The quality of certain electrolytes deteriorates during lengthy storage. This applies especially to A-2 which, when the components have been mixed, has a useful life of no more than 2-3 months. For this reason the two components are normally supplied separately so that they may be mixed directly before use. In mixed state the A-5 will keep for about half a year. The other electrolytes have a useful life of half a year or perhaps a little more. IT SHOULD BE NOTED, HOWEVER, THAT THE USE OF THE ELECTROLYTE IS THE MOST IMPORTANT CAUSE OF DETERIORATION. All electrolytes must be replaced when they contain an excessive amount of metal ions.

4. Thinning Examples.

4.1. Thinning in the 10 mm specimen holder.

Material	Electrolyte	Temperature	Flowrate	A	V	App. time for removing 0,1 mm in seconds
Aluminium	A-7	-5			12	
Copper	D-2	15	6-7	1,8	28	140
Brass	D-2	15	6-7	1,2	20	150
Phosphor-bronze	D-2	15	6-7	1,6	28	160
Nickel	A-8	15		0,9	115	190
Stainless Steel	A-8	15		0,8	110	220
Carbon Steel	A-8	15	5-7	0,9	115	170
Iron	A-8	15			110	
Zirconium	A-8	15	5-7	0,7	70	140

4.2. Thinning in the 3 mm specimen holder.

Material	Electrolyte	Temperature	Flowrate	A	V	App. time for removing 0,1 mm in seconds
Aluminium	A-7	-5		0,12	12	45
Copper	D-2	15	4	0,3	15	50
Brass	D-2	15	4	0,10	8	70
Phosphor-bronze	D-2	15	4		12	
Nickel	A-8	13	slow	0,13	70	60
Stainless Steel	A-8	13	very slow	0,13	70	75
Carbon steel	A-8	13	slow	0,16	80	50
Iron	A-8	13				
Zirconium	A-8	13	slow	0,05	30	120

5. Polishing defects.

If a sufficiently high quality is not obtained in electrolytic polishing it will be necessary to alter the polishing conditions. Five important degrees of freedom are available:

a. the electrolyte,
b. the flowrate of the electrolyte,
c. the temperature,
d. the electrical conditions and
e. the geometrical conditions.

In the TENUPOL the geometrical conditions are fixed and can only be altered by changing or altering certain components.
As to the other degrees of freedom the following will apply:

a. The chemical composition of the electrolyte is highly important for the quality of the polishing. An unsuitable electrolyte will cause inferior polishing, oxidized or etched surface, pittings or one-sided polishing, i.e. only one side of the specimen is polished, the other is black and oxidized. It is not at all certain, that an electrolyte, which in other apparatus, (e.g. the LECTROPOL) will polish a certain material, will also be suitable for thinning it on the TENUPOL. A-2, for inst. is not suitable for use with TENUPOL.
In the litterature numerous examples are cited of electrolytes suitable for thinning. (See e.g. I.S. Brammer and M.A.P. Dewey: Specimen preparation for Electron Metallography. Blackwell Scientific Publications, Oxford 1966).

b. The flowrate determines first of all whether a viscous anodic layer can be maintained during polishing. Jet polishing tends to remove the layer. The proper choice of flowrate is therefore mostly determined by the material to be polished and on the electrolyte. The best flowrate differs much from case to case and it is not possible to give general rules.

c. In some cases a lower temperature will give better results. A lower temperature slows down the polishing and provides less etching and oxidation.

d. The electrical conditions of course determine whether a polishing is at all obtained. The right conditions will only be present within a certain range of current densities. If a current versus voltage curve is drawn the best polishing conditions will be found where the current is approximately constant within a range of voltages. Moreover, some workers have found, that a better polish is obtained on some materials, if towards the end of the process the current is applied as a series of chocks.

In TENUPOL polishing, the polishing defects may be divided in the following classes:

1. Defective polishing, i.e. wrong polishing conditions, so that a mirror-like finish is absent on one or both sides of the specimen. Pitting may be present.

2. Polishing takes place, but no thin area is present at the edge of the hole.

Re 1: Try to alter the electrical conditions. Perhaps the voltage was too low to reach the polishing range. Pittings may arise if the current was too high. A lowering of the temperature may make the polishing less sensitive to voltage changes. The flowrate should be altered. A too high flowrate may break up the polishing film, which may be the cause of one side of the specimen not being polished. A slower flow may allow a polishing film to be built up.
If nothing helps it can be concluded, that the material in question cannot be polished by the electrolyte and another electrolyte should be tried.

Re 2: The hole may have grown toc large, so that the thin foil first formed has disappeared. Just like electropolishing will attack the tops of the asperities of the surface, it will attack the edge of the hole as being an asperity. Especially when the jet effect is strong it is very important to stop the process while the hole is small.
Adjustment of the flowrate may be helpful. A vigorous jet may attack a too small area. Another electrical current density should also be tried. Sometimes a lower temperature will give a better profile around the hole, possible on account of a change of viscosity.
If nothing helps it is probable, that the electrolyte is not suitable for thinning the material in question, although it will electropolish it. Try another electrolyte.

6. Cleaning and maintenance.

Residuals of the electrolyte used previously may spoil the following polishing. Therefore it pays to rinse the polishing cell and pump well before filling in a new electrolyte. This may be done as follows:
The electrolyte tank is filled with water and this is pumped through the system in the usual way. After this rinsing the pump and polishing cell should be allowed to drip off, in order, that the electrolyte is not diluted by water. If copper or copper alloys have been thinned, some copper may have deposited on the cathodes. This may be removed with a few drops of nitric acid before the rinsing.

The TENUPOL should not be left filled with electrolyte for an unnecessarily long time, as the submerged parts may be attacked somewhat.
Especially A-8 will shorten the life of the metal parts.
Never turn the apparatus upside down, especially not when there is electrolyte in the pump, as this may trickle from the pump up to the motor and cause the axle to stick. Take care, that the motor housing does not come in contact with the electrolyte. The apparatus may be cleaned on the outside with a cloth moistened with methanol or alcohol.
During the guarantee period any repair must only be performed by Struers or Struers' dealers. Also after the expiration of the guarantee period it is recommended to let Struers or Struers' dealers or other competent personnel take care of repairs.

SPARE PARTS LIST

Apparatus: TENUPOL

See drawing: No. 255-M-176 and fig. 4.

Pos.No.	Description	Spare Part No.
1	Polishing chamber complete	255 MP 1
2	Glass window	255 MP 2
3	Inlet tube	255 MP 3
4	Outlet tube	255 MP 4
5	Nozzle-unit, complete 1 mm dia.	255 MP 5
6	Nozzle-unit, complete 2,5mm dia.	255 MP 6
7	Magnifier	255 MP 7
8	O-ring, 32/26 dia.	255 MP 8
9	O-ring, 76,36/71,42 dia.	255 MP 9
10	Thumb screw for lamp housing	255 MP 10
	Thumb screws for photocell	255 MP 11
12	Contact spring	255 MP 12
13	Spring for bulb	255 MP 13
45	Bulb 3,5 V	255 MP 45
14	Sample-holder, complete, 3mm	255 MP 14
15	Sample-holder, complete, 10mm	255 MP 15
16	Cooling coil complete	255 MP 16
17	Holder for cooling coil	255 MP 17
	Pump housing (before no.255125)	255 MP 18
20	Impeller	255 MP 20
21	Roll for impeller	255 MP 21
22	Pump shaft	255 MP 22
	Pump cover with screws (before no. 255125)	255 MP 23
24	Coupling	255 MP 24
25	Pump holder	255 MP 25
	Elbow pipe	255 MP 26
	Stopper	255 MP 27
28	Y-tube	255 MP 28
29	P.V.C. tubing	255 MP 29
30	P.V.C. tubing	255 MP 30

Pos. No.	Description	Spare Part No.
31.	Motor	255 MP 31
32.	Transformer	255 MP 32
33.	Noise filter	255 MP 33
34.	Switch	255 MP 34
35.	Lamp red	255 MP 35
36.	Lamp green	255 MP 36
37.	Fuse	255 MP 37
	Printed board for motor	255 MP 38
39.	Printed board for photocell	255 MP 39
40.	Short circuiting board	255 MP 40
	Connector, female	255 MP 41
	Connector for connection to LECTROPOL	255 MP 46
47.	Screw for lamping housing (new type)	255 MP 47
48.	O-ring 29/23 dia.	255 MP 48
49.	Oil packing	255 MP 49
	Spring for platinum contact foil	255 MP 50
51.	Lock ring	255 MP 51
52.	Pump cover (from no.255125)	255 MP 52
53.	Hose clamp	255 MP 53
54.	Pump housing with pipe (from no.255125)	255 MP 54
	Extension Kit	255 MP 55

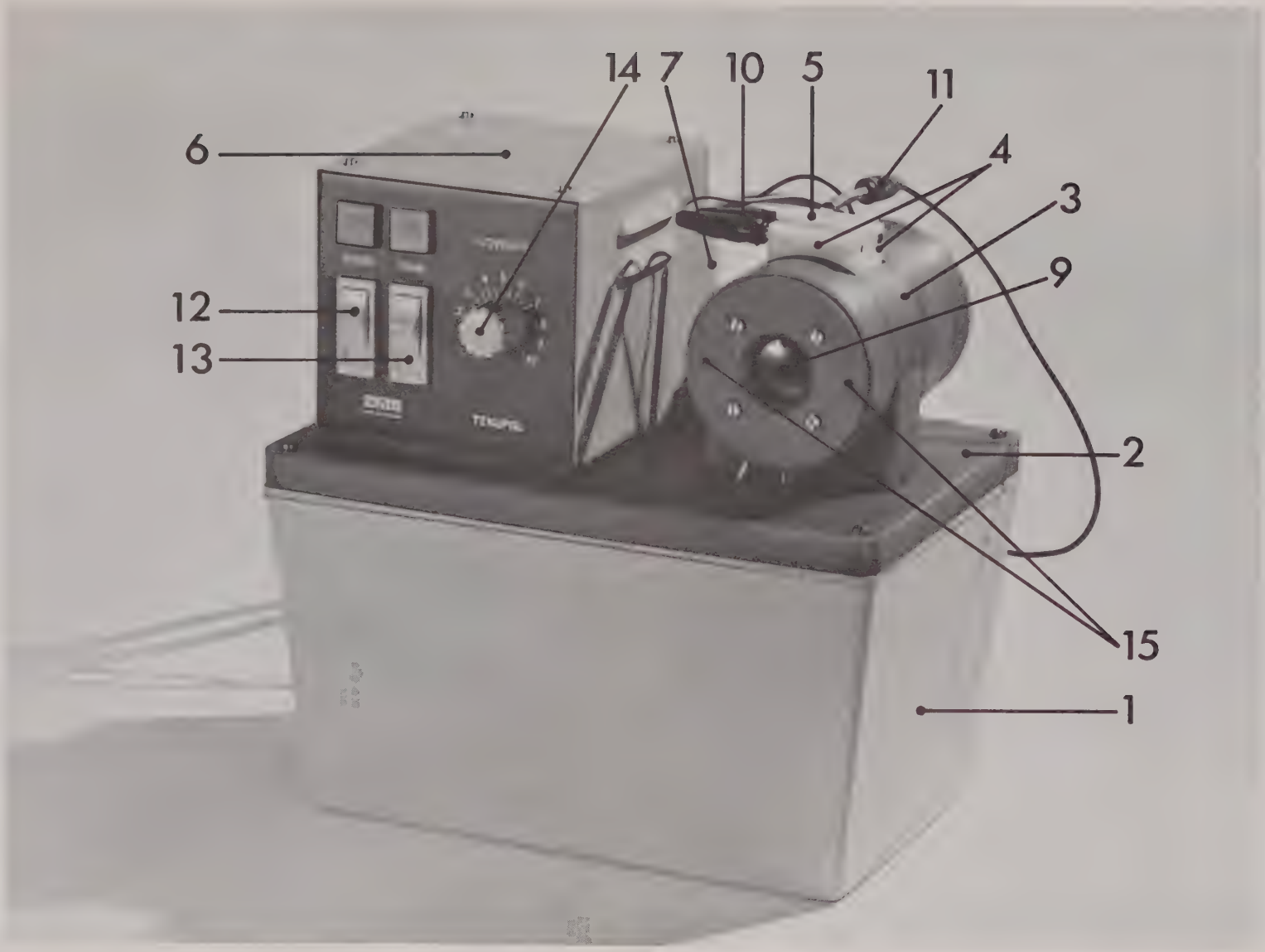


Fig. 1

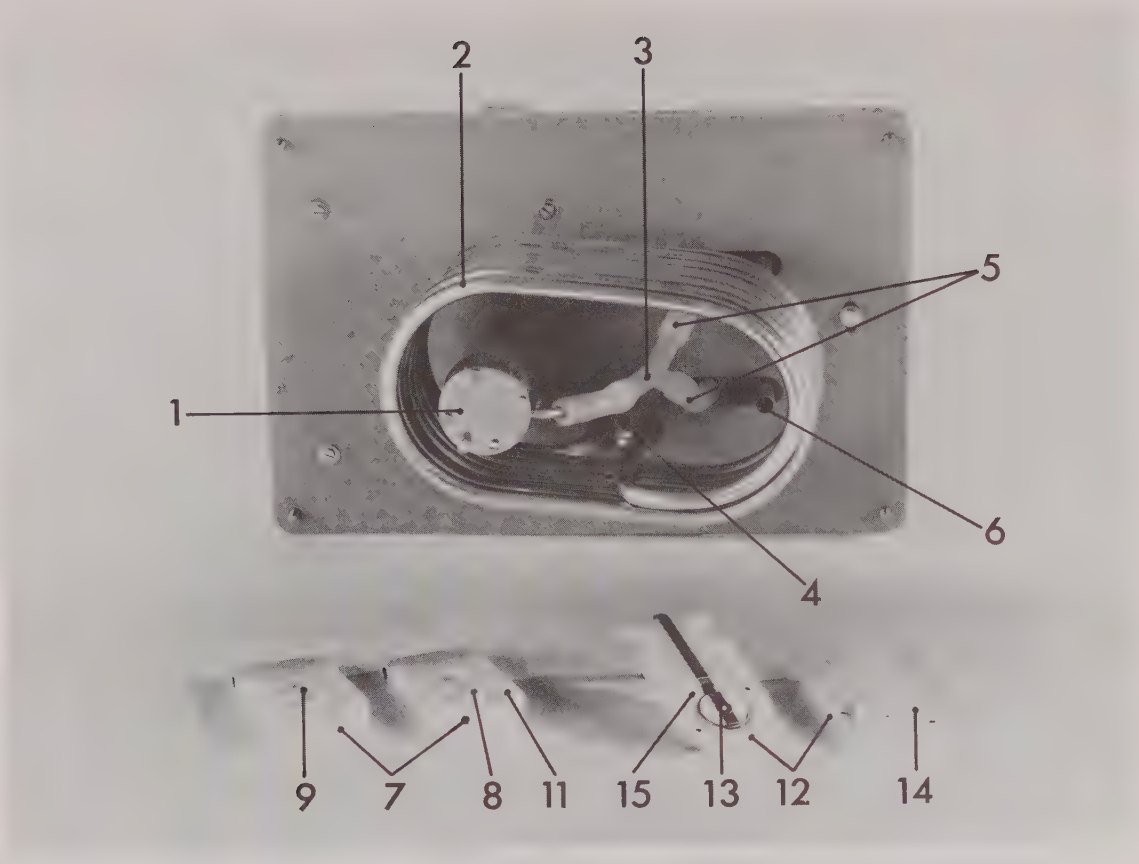


Fig. 2

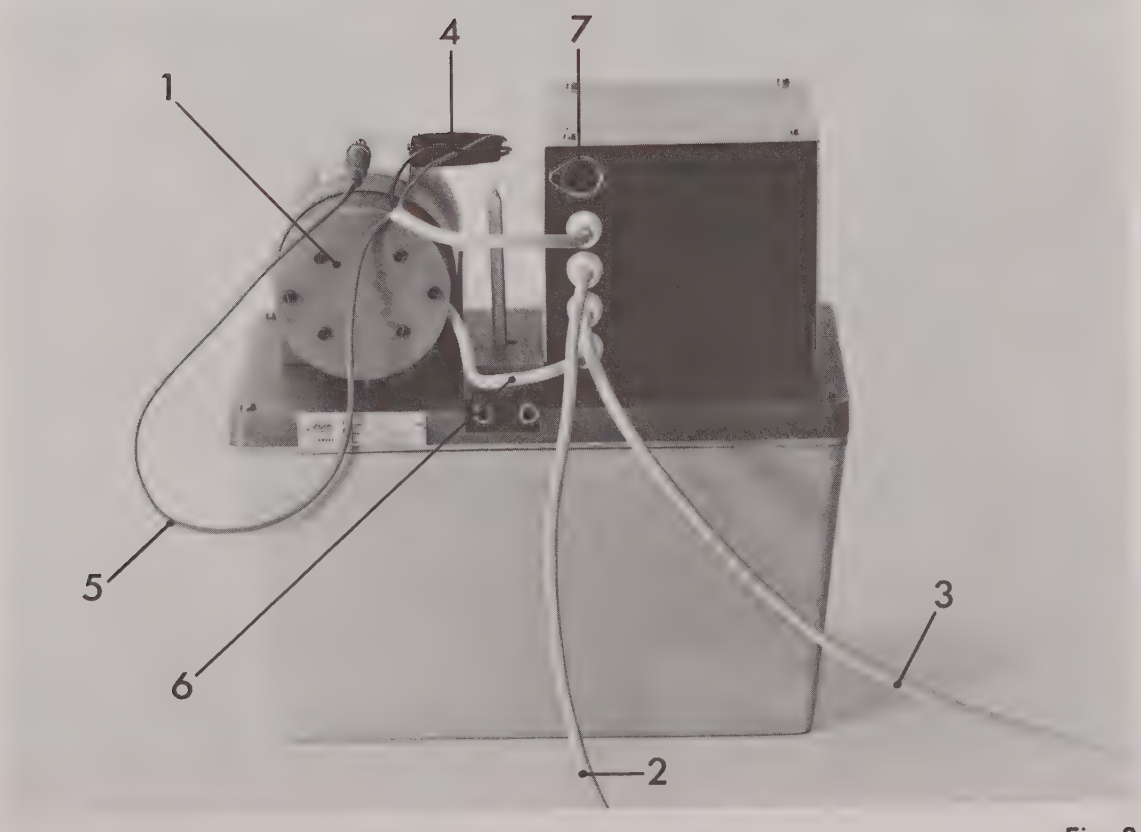
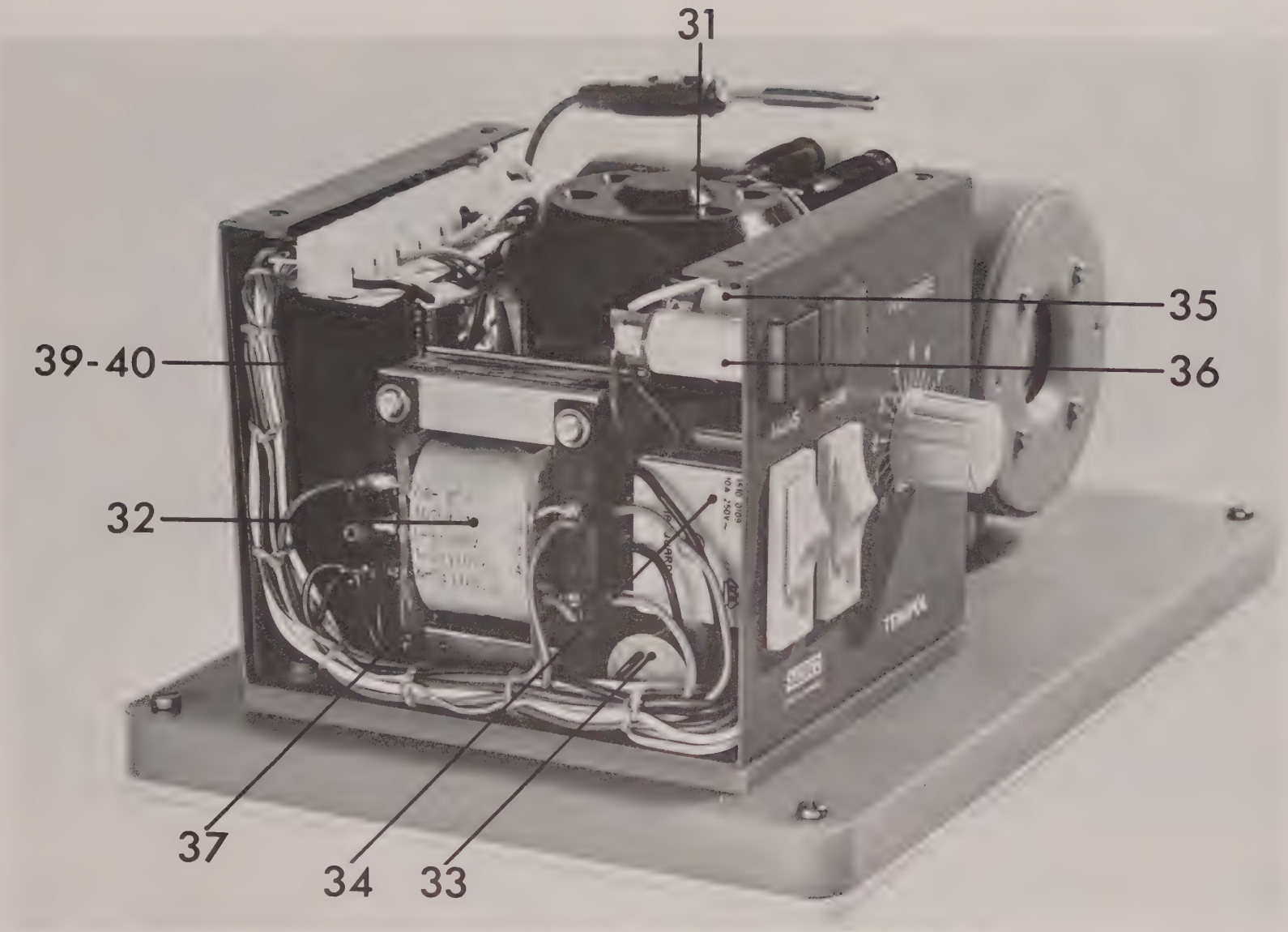
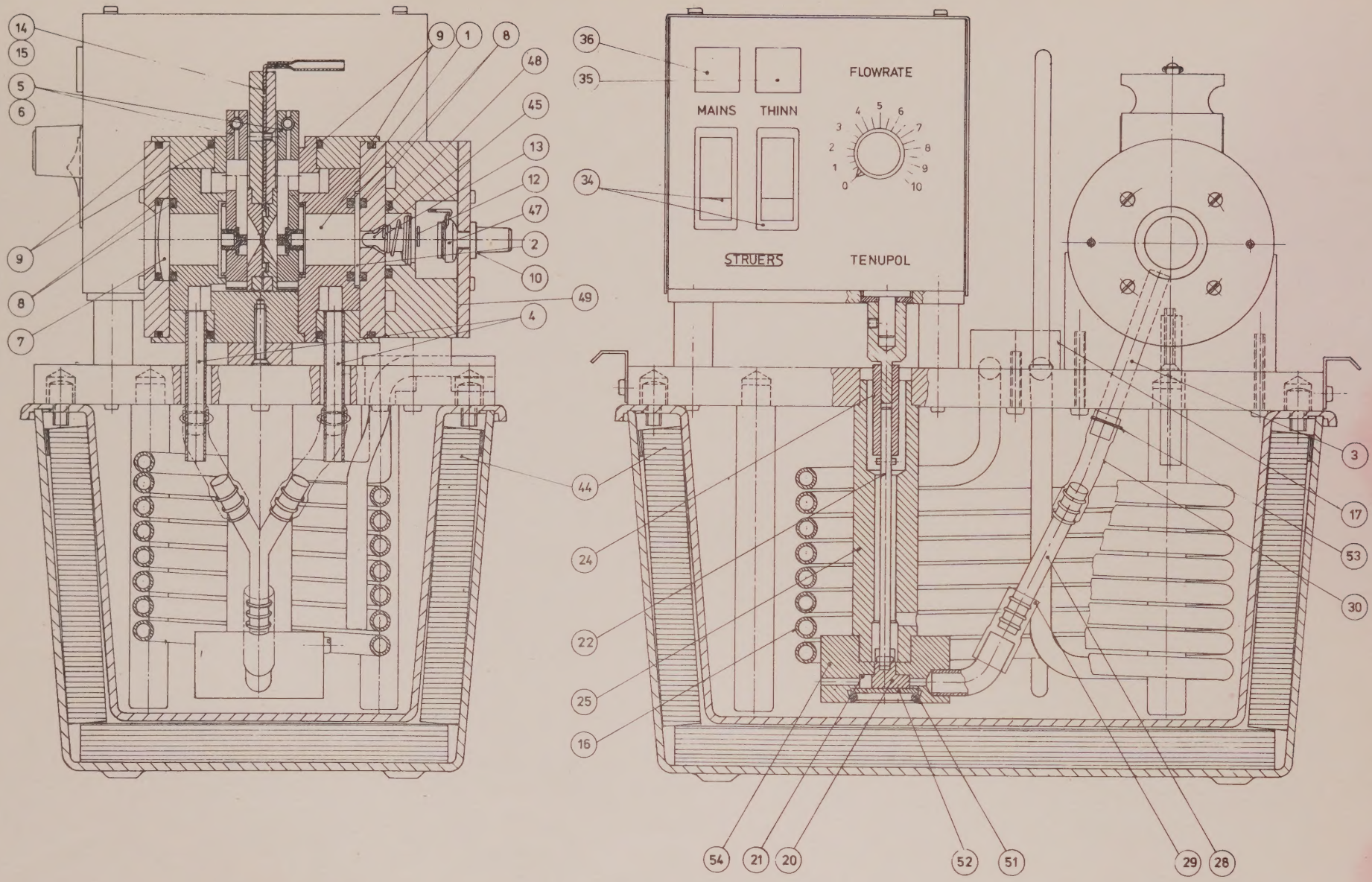


Fig. 3



TENUPOL

Fig. 4



TENUPOL
Drawing no. 255-M-176

MP MASTER
MA32802